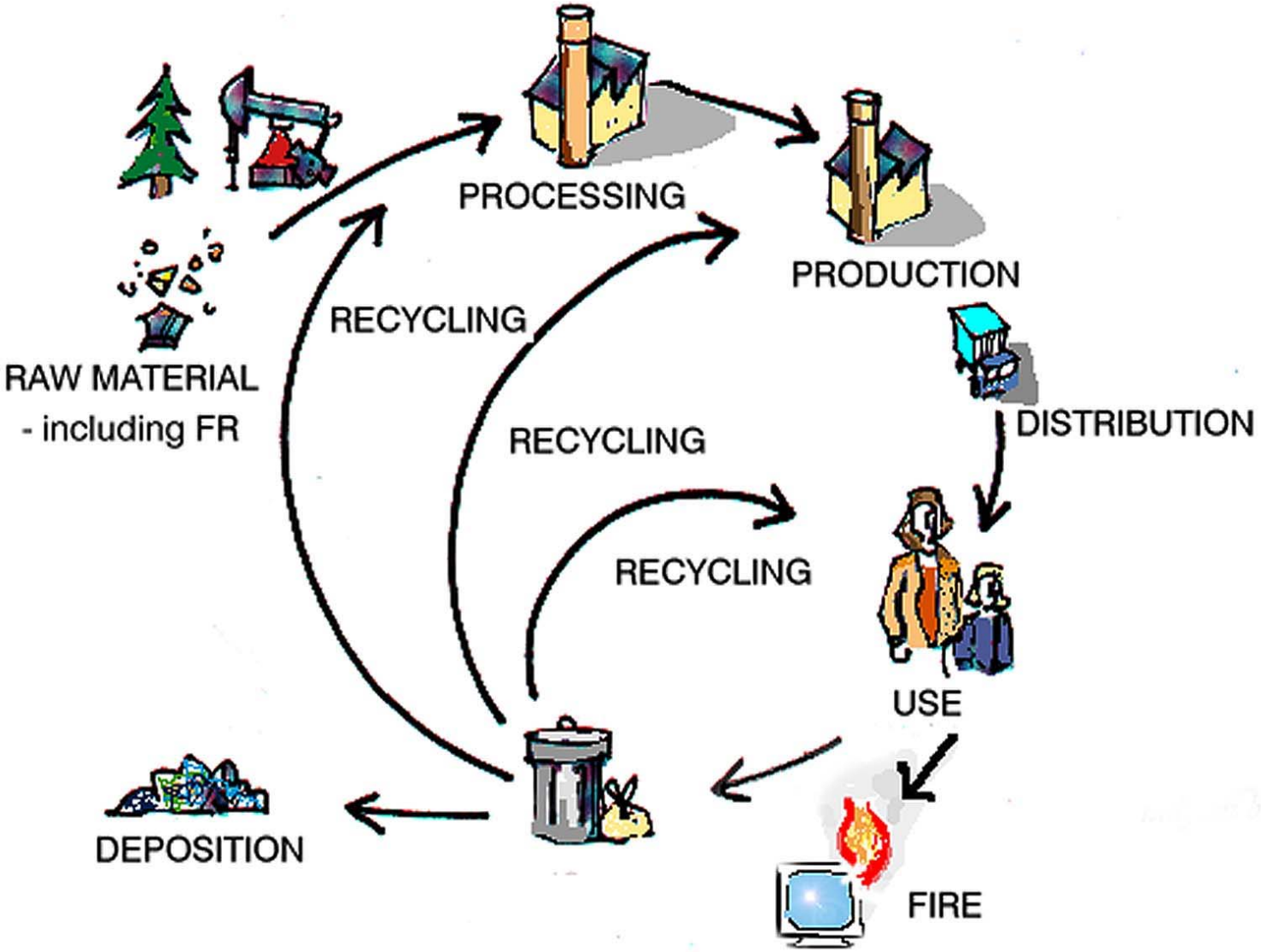
Life Cycle Assessment of Fire Retardants

Dr. Margaret Simonson McNamee
Research Manager
SP Fire Technology

Flame retardants

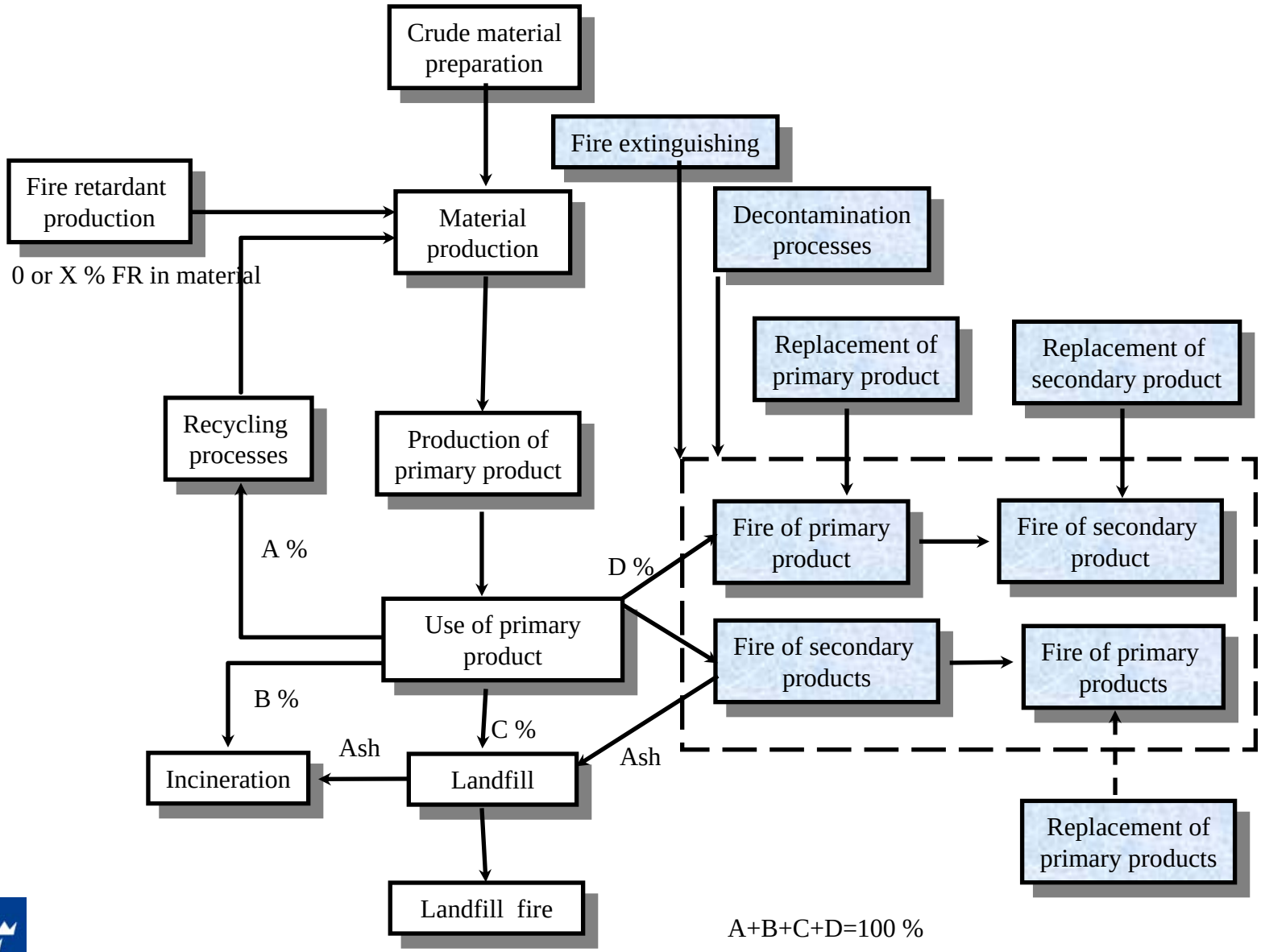
- Environmental effect discussed since 1980’s
- Qualitative analysis too subjective
- SP and partners developed quantitative analysis method developed based on LCA (start mid-90’s)
- Risks
  - Exposure during manufacture, use, disposal
  - Fires
- International legislation, one of many drivers

Fire-LCA model



Fire-LCA Model: Aim

- Evaluate environmental benefits of a flame retardant (FR) relative to the environmental costs of their production and use
- Traditional eco-evaluation of FRs:
  - Concentrate on perceptions of hazard rather than risk
  - No effort made to consider risks associated with fires, i.e., functionality of FRs marginalised


Crude material preparation
Fire extinguishing
Fire retardant production
Material production
Decontamination processes
0 or X % FR in material
Replacement of primary product
Replacement of secondary product
Recycling processes
Production of primary product
A %
D %
Fire of primary product
Fire of secondary product
Use of primary product
Fire of secondary products
Fire of primary products
B %
C %
Ash
Ash
Incineration
Landfill
Replacement of primary products
Landfill fire
A+B+C+D=100 %

Fire Statistics

- Most countries keep detailed fire statistics
- Variation between sources within a country and between different countries
  - Fire brigade – typically large fires
  - Insurance companies – both large and small fires
  - Differences due to different regulations between countries, e.g. USA and Europe

TV Case Study

Investigate the environmental impact of choosing higher level of fire safety in enclosure material

TV Fire Severity, Fire Statistics Model

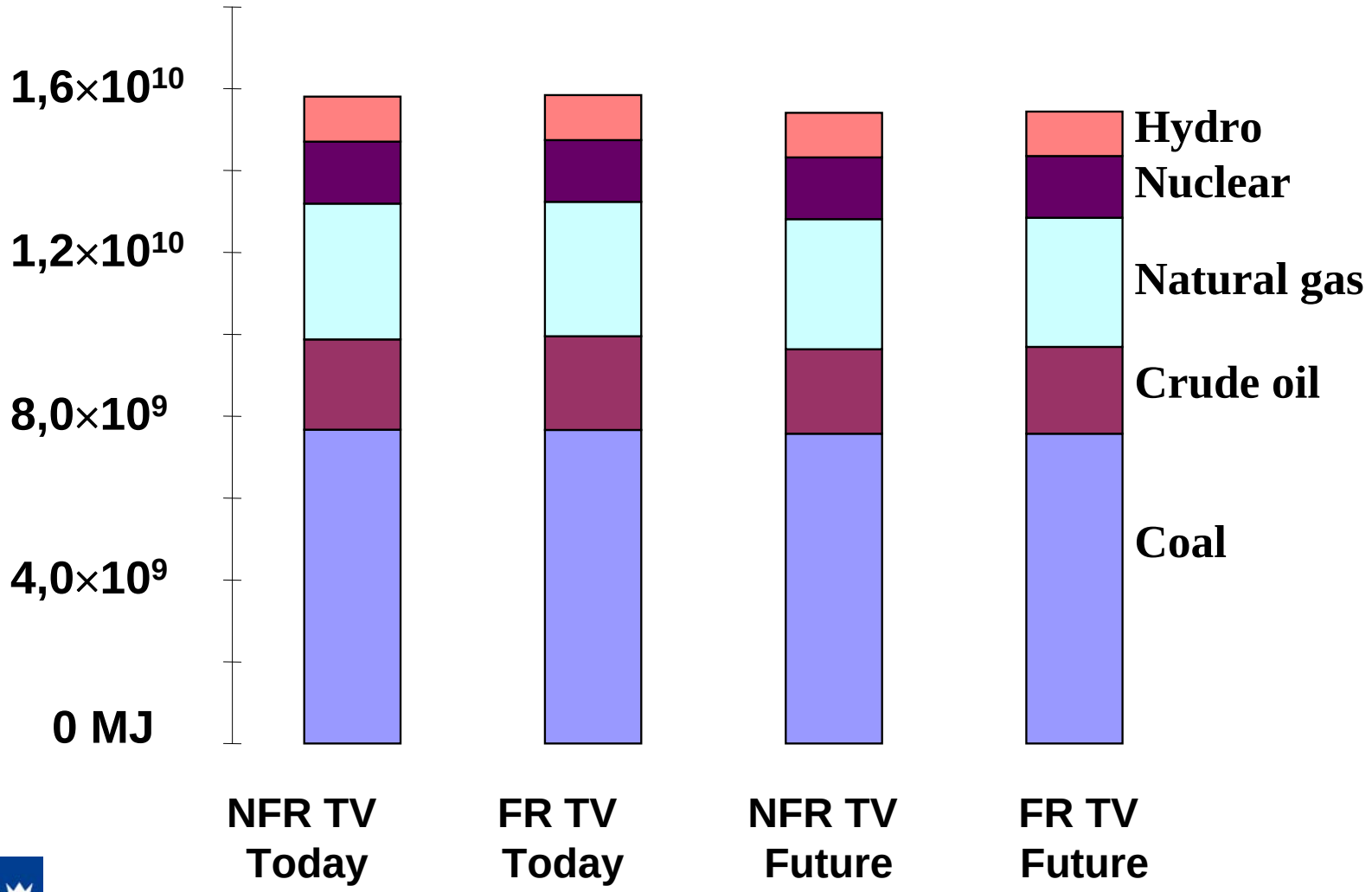
- Statistical model based on European and US statistics
- Division of fire sizes into: minor, full TV, full room, full house

Euopean TV			US TV		
Primary	**F**	**R**		**F**	**R**
160 minor, 30% replace		×	160 minor, 30% replace		×
58 minor, 100% replace		×	5 minor, 100% replace		×
88 TV only	×	×			
8 full room	×	×			
11 full house	×	×			
Secondary					
4 full house (6 TV only)	×	×	4 full house (6 TV only)	×	×

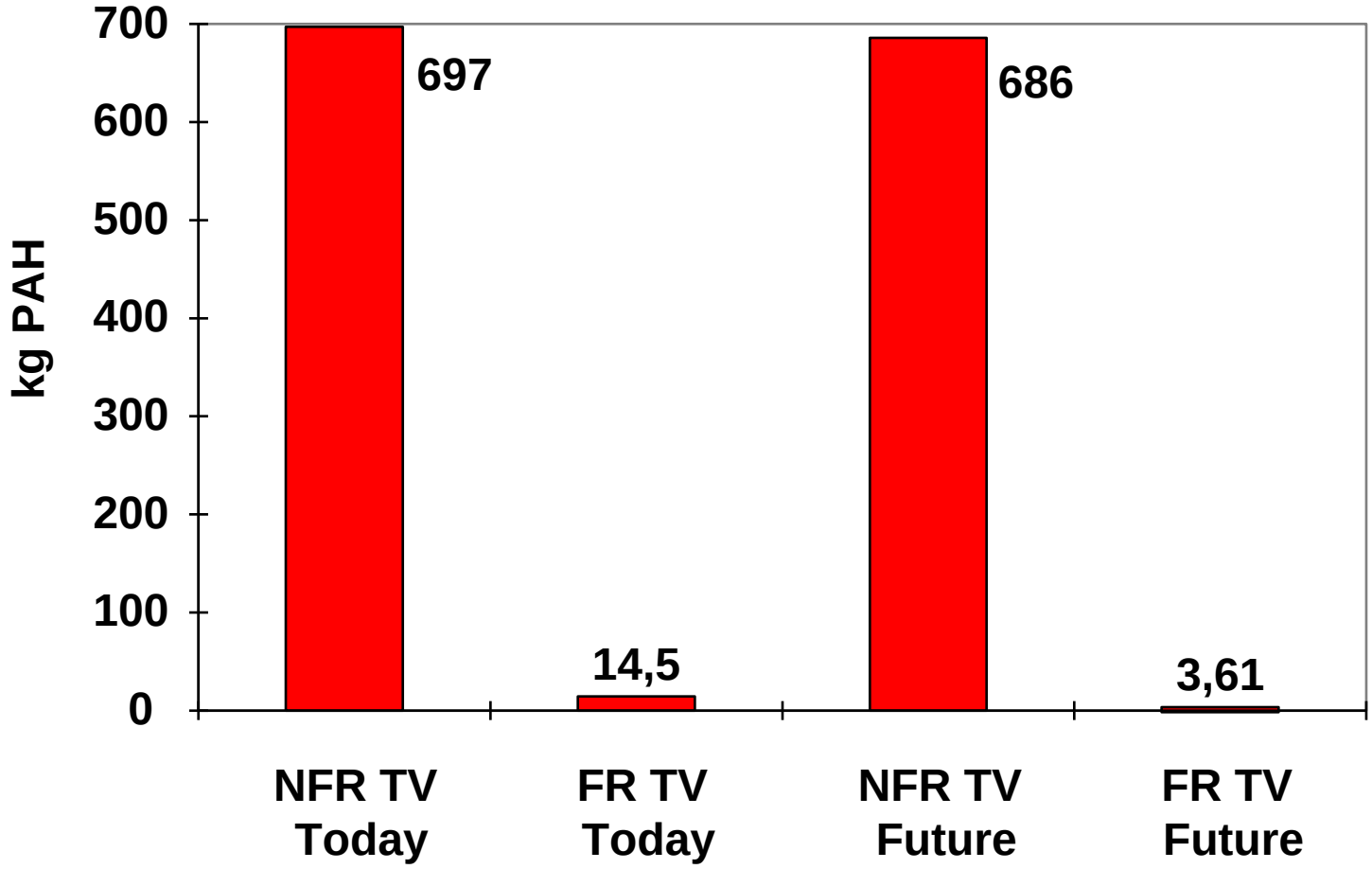
LCA Results - Scenarios

Present	Future
1 % Incineration 2 % Disassembly ~97 % Landfill (+ Fires)	1 % Incineration 89 % Disassembly ~10 % Landfill (+ Fires)

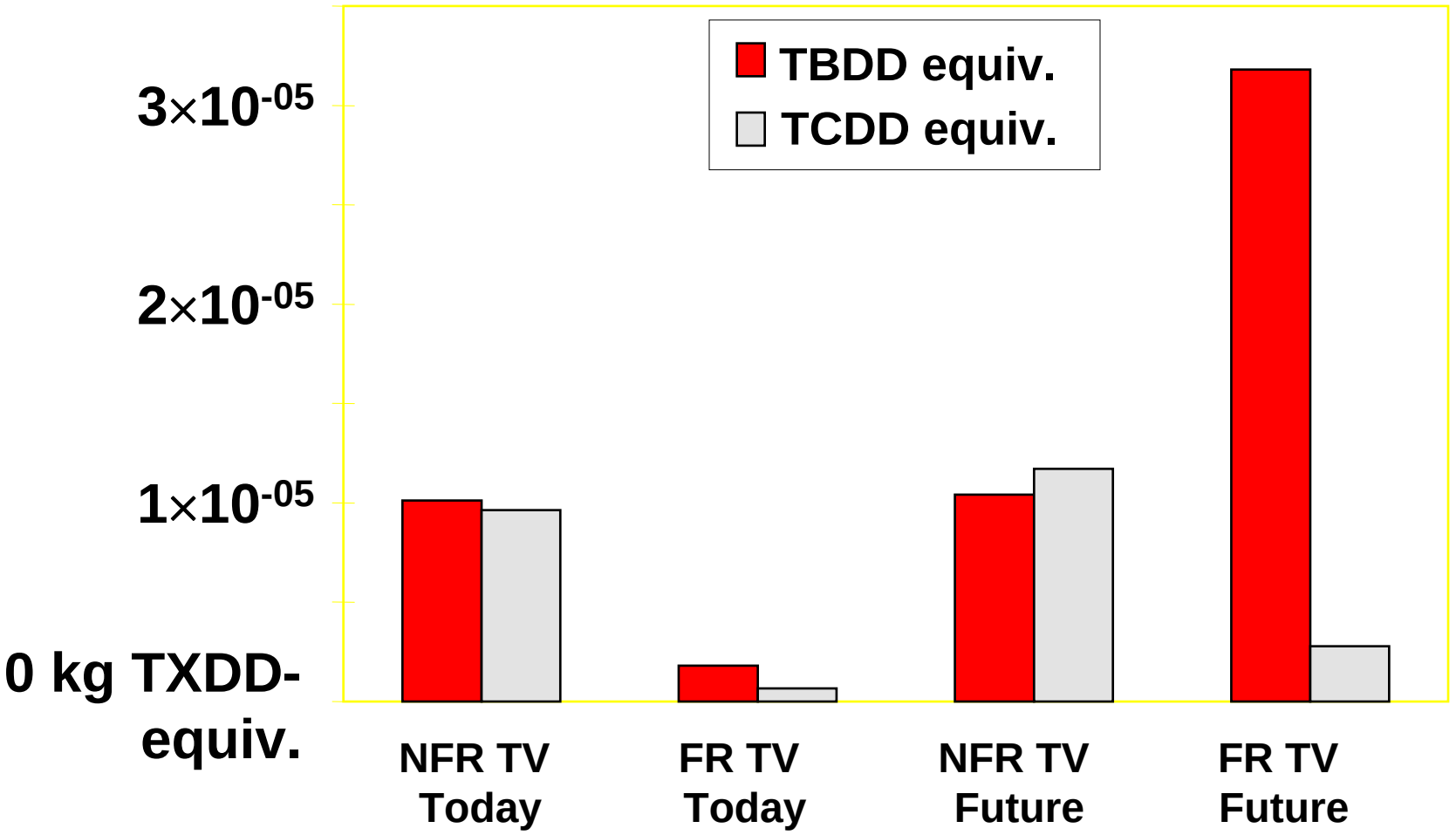
Energy Use (10^6 TVs, 10 years)



PAH emissions to air (10^6 TVs, 10 years)



TXDD-equivalents to air (10^6 TVs, 10 years)



Why are PAH, TXDD-equiv. lower for US TV

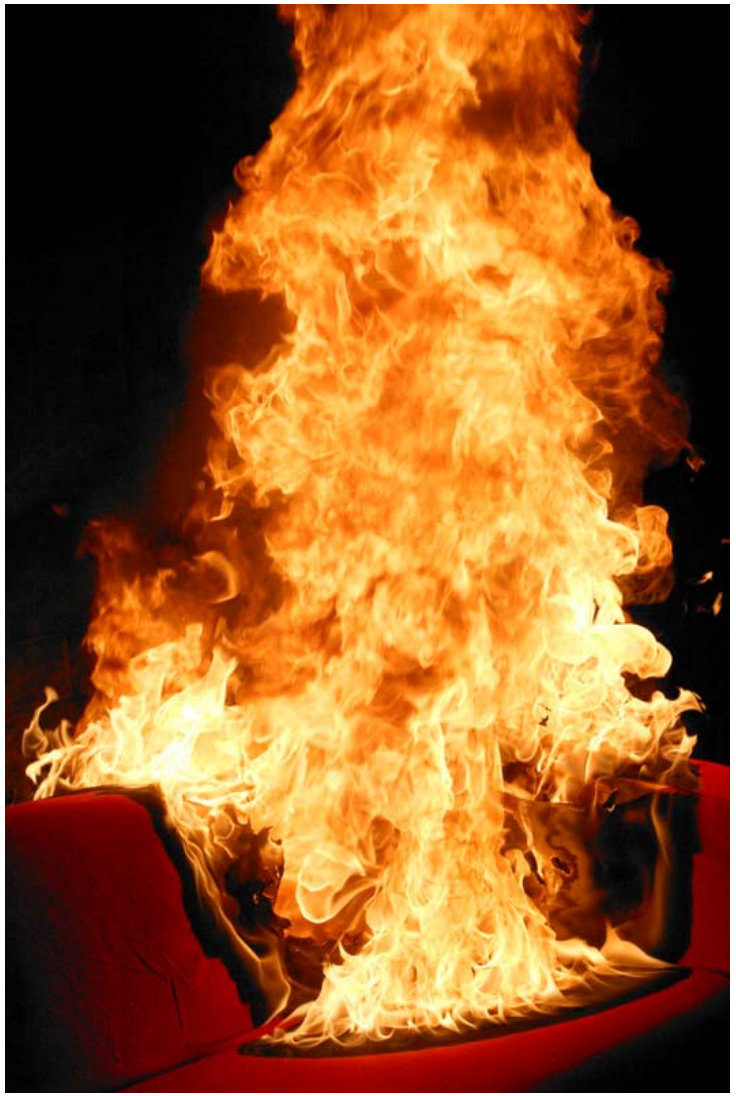
- Minimised from controlled combustion (TBDD-equivalent is a special case due to allocation)
- Major constituents of fire cases from flashed-over fires
- European TV Fire Statistics model has European TV involved in more and larger fires

Conclusions

- Minor energy difference between US and European TVs
- Fires insignificant source of CO, CO_2, NO_x ….
- European:US TV-difference most marked for large organic species
- PAH most significant toxicologically
- Full risk assessment must consider risk for death and injury:
  - Conservative estimate: 16 dead, 197 injured in Europé each year from TV fires
  - Upper limit: 160 dead and 2000 injured

Furniture Case Study

Investigate the environmental impact of choosing higher level of fire safety in sofa

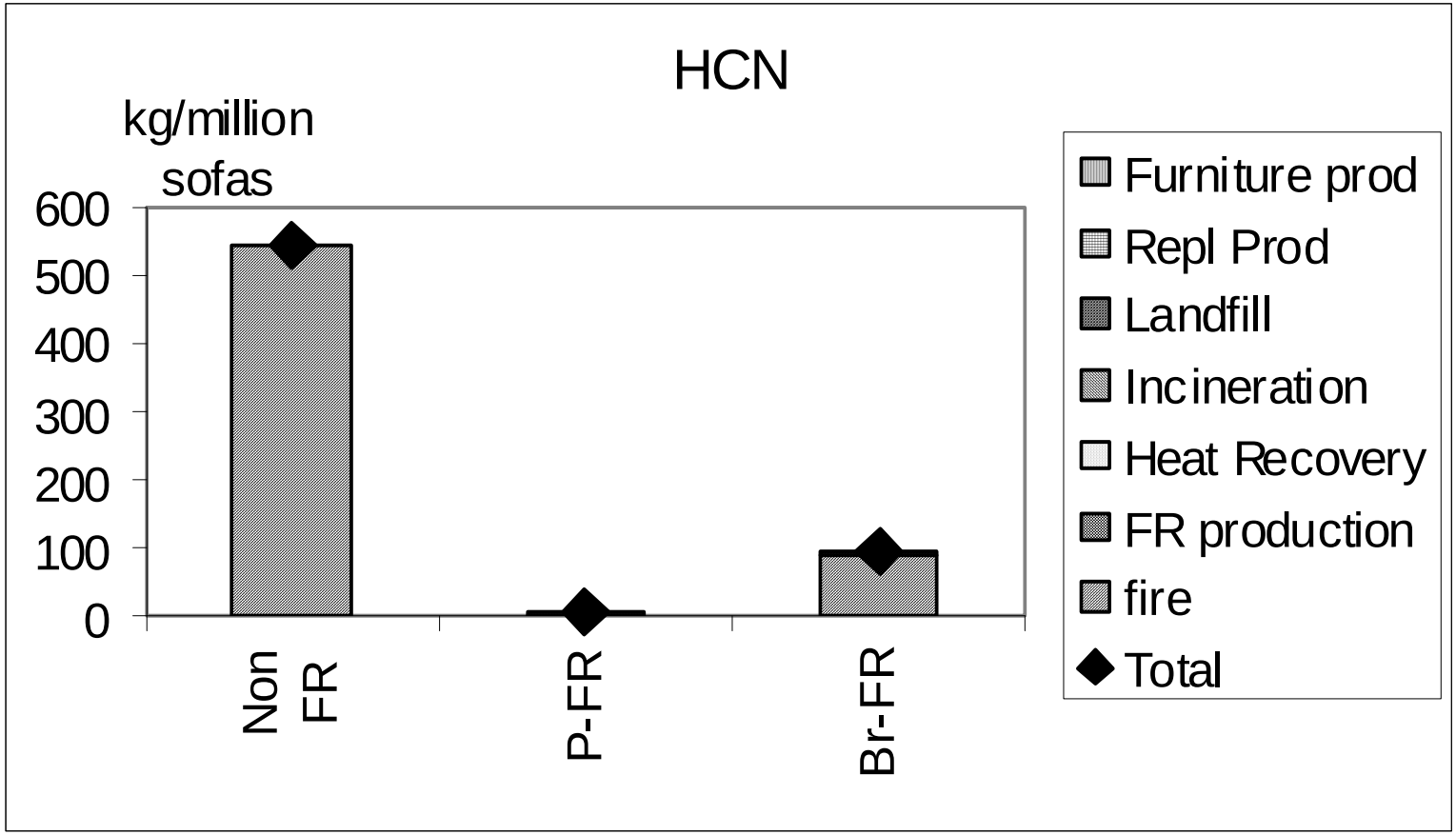


Sofa Fire Severity, Fire Statistics Model

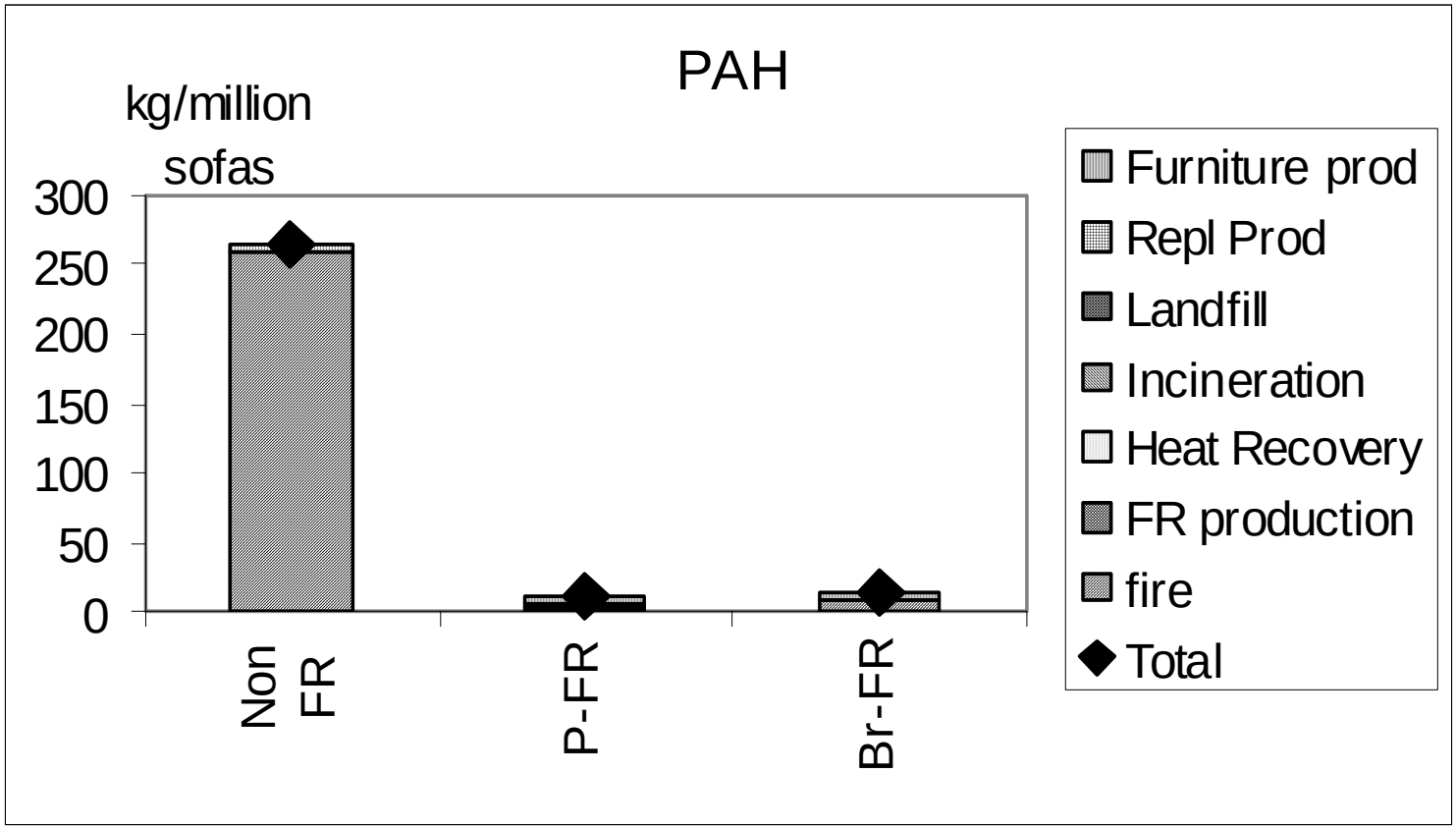
- Statistical model based on UK and mainland European statistics

Fires/million sofas	FR sofa	Non-FR sofa
Primary fires		
Small fires	215	187
Starting in sofa	0,33	28
Confined to sofa	0,18	12
Confined to room	0,12	14
Confined to building	0,03	2,5
Secondary fires		
Confined to room	69	69
Confined to building	115	115

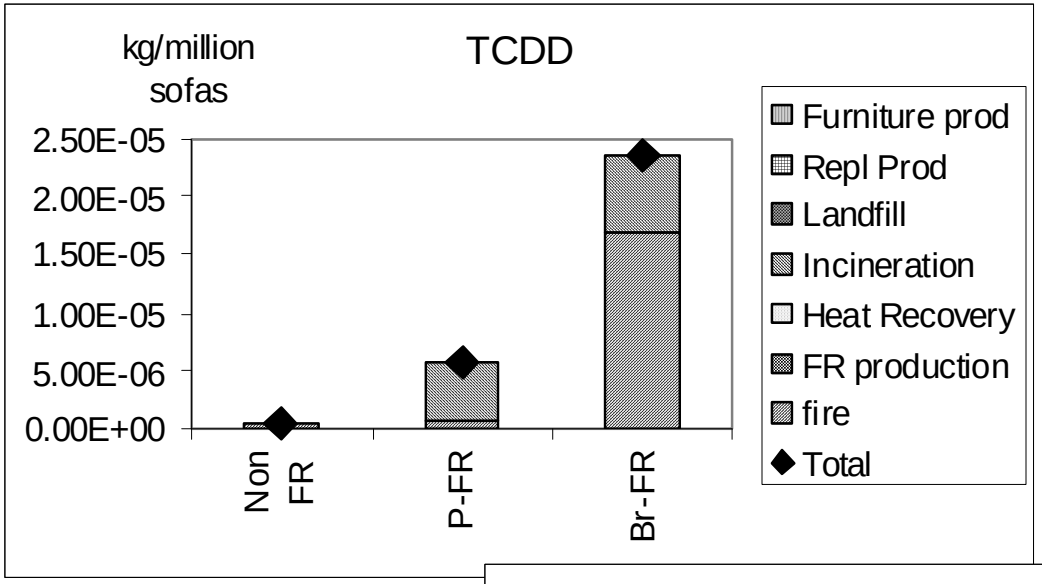
HCN emissions to air (10^6 Sofas, 10 years)

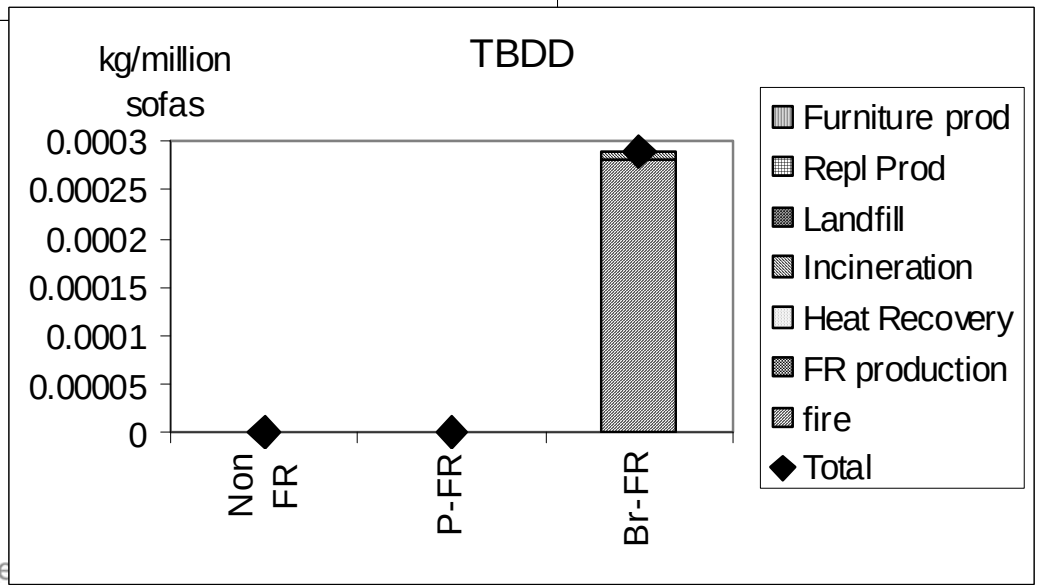


PAH emissions to air (10^6 Sofas, 10 years)



TXDD-equivalents to air (10^6 Sofas, 10 years)





PAH and dioxin background levels

- Chlorinated dioxins and furans from sofa fires approximately 0,003% of background emission in UK each year
- PAH from sofas approximately 1% of emissions from fires each year (0,05 % of background from all sources)

Conclusions

- Minor energy difference between FR and non-FR sofas
- Fires insignificant source of CO, CO_2, NO_x
- Fires important source of PAH, HCN, dioxins and furans
- PAH most significant toxicologically
- Use of flame retardants in upholstered furniture does NOT have an adverse impact on the environment based on this study (toxicology not included)
- Full risk assessment must consider risk for death and injury
- Available evidence demonstrates (UK) that the use of flame retardants can significantly improve the fire performance of furniture thus reducing fire death and injuries

Fire emissions have a significant potential to effect both people and the Environment